JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammologists

VOL. 3 AUGUST, 1922 No. 3

THE BREATHING OF THE FLORIDA MANATEE (TRICHECHUS LATIROSTRIS)

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A man may live some two months without food, a week or more without water, but only a few minutes without air. This dependence upon an almost immediate supply of oxygen is characteristic not only of man but of all other warm-blooded vertebrates. All such animals die sooner from lack of air than from lack of water or of food. But a number of these warm-blooded forms, both among the birds and the mammals, have adapted themselves to temporary life under water where they are for all practical purposes cut off from the oxygen of the air.

Among the birds the divers exhibit this peculiarity conspicuously, but the recent observations of Alford (1920), of Bolam (1921) and of Taylor (1921) show that ducks and grebes stay under water scarcely a minute and usually not over half a minute.

In this respect the water birds are far exceeded by a number of mammals especially by those that live in the sea, as, for instance, the whales, porpoises, and other cetaceans. Beale (1839, p. 44), who was a surgeon on a whaler and was reputed a good observer, declared that sperm whales could remain under water from an hour to an hour and twenty minutes, and Andrews (1916, p. 57) quotes a case reported by Captain Melsom of a blue whale that remained below the surface 50 minutes, then spouted 20 times, and again went down for 40 minutes. Andrews himself (1909) recorded an instance of a humpback whale that remained under water 20 minutes and of a finback that was under 23 minutes. Whether the older records of an hour or more of submergence will be confirmed or not is a question for the future to settle,

but quite aside from this the very fact that cetaceans may live twenty minutes or more without direct access to air is in itself a most remarkable condition and shows how highly specialized these creatures are as compared with their near relatives the terrestrial mammals.

In addition to the cetaceans the seals and especially the sea-cows or sirenians are mammals that lead an aquatic existence. In fact it is probable that the sea-cows, like the cetaceans, never come upon land at all, but remain always in the water. They inhabit the shallow seas of the warmer regions and are common about the mouths of rivers which they ascend for considerable distances. They are inoffensive quiet creatures feeding upon sea-weeds and other aquatic plants. The east coast of Florida is inhabited by a single species, *Trichechus latirostris* (Harlan), which can often be seen in the waters of Biscayne Bay near Miami. It was during my sojourn at the laboratory of the Miami Aquarium Association, at Miami Beach, Florida, that I had the opportunity of studying three of these animals which were contained in a large outside basin on the grounds of the aquarium. I am indebted to the officers of the Miami Aquarium Association for the opportunity I there had of observing the habits of these sea-cows, especially their respiration, under conditions that were as near natural as possible.

The three sea-cows or manatees, as they are commonly called, had been confined in the aquarium nearly a year. In the course of that time they had become extremely tame and lived a life of sluggishness much as they do in nature. They fed freely on cabbage leaves and appeared in all respects to be in excellent condition. After a full meal they would lie quietly in the water often for hours at a time, their apparent repose being interrupted only by an occasional rising to the surface for air. As is well known they rest under water in a curved position with the head and tail depressed and the back arched up and near the surface. When they rise to breathe, the back usually breaks the surface of the water first, after which the head emerges. Expiration and inspiration are then quickly accomplished whereupon the animal slowly sinks again below the surface of the water. Two or three such respiratory acts commonly occur, one quickly following the other, after which the manatee sinks into the water to remain quietly there for a considerable period. These operations are carried out with slowness and regularity so that it is comparatively easy with a watch in hand to take complete records of as many as three animals at one time.

The three manatees at the Miami Aquarium were of very different sizes so that they were easily distinguishable. The largest one was a female of about three meters in length. The next in size was a male about two and a quarter meters long. And the smallest was a young one of undetermined sex somewhat less than two meters from snout to tail. In the late afternoons these three animals were commonly found lying nearly parallel one to the other and exhibiting no other motion than the occasional respiratory one already described. Under such circumstances continuous records could be kept of the breathing of the animals for periods well over an hour. Each set of records included the lengths of time covered by the breathing periods, the number of breaths in each period, i.e., the number of times the nostrils were brought to the surface and opened and closed, and finally the resting periods or lengths of time each manatee remained quietly resting under water. The details of three such sets of records, each covering about an hour, are given in table 1.

It is evident on inspecting table 1 that in all three sets of records the young manatee came most frequently to the surface to breathe, the male less frequently and the female least frequently. The details of this table are, however, best appreciated by a comparison with table 2 which gives in compact form the general averages from table 1.

On comparing these two tables it will be seen that the breathing period in the young manatee varied from 20 seconds to 3 minutes and averaged 49 seconds. In the male it ranged from 20 seconds to 3 minutes and 20 seconds and averaged 1 minute. In the female it ran from 20 seconds to 3 minutes and averaged 1 minute and 17+ seconds. Although the range in the length of the breathing period is much the same for the three individuals, table 1 shows that short periods are more characteristic of the young, longer ones of the male, and still longer ones of the female.

The numbers of breaths taken in the breathing periods by the three manatees vary in each instance between 1 and 4 except that there is one record of 5 in the breathing of the male. Nevertheless table 1 shows that the young takes a smaller number of breaths, average 1.7—, than the male, average 2.2, and the male a smaller number than the female, average 2.6.

Although it is true that the young manatee came to the surface more frequently than the male and the male more frequently than the female, and, further, that the young one took fewer breaths per period than the male, and the male than the female, it is also true that

TABLE 1

Breathing records of three Florida manatees (Trichechus latirostris) taken from the animals in the Miami Aquarium, set A on June 10, set B on June 13, and set C on June 14. Each set covers a period of about an hour and includes records from a young animal less than two meters long, from a male about two and a quarter meters long, and from a female about three meters long. The breathing periods are given in minutes and seconds. The number of breaths indicates the number of times the head was brought to the surface and the nostrils were opened and closed in each breathing period. The resting periods show the lengths of time in minutes and seconds spent quietly under water

SETS	ANIMALS	PERIODS, ETC.	TIMES IN MINUTES AND SECONDS, ETC.												MEANS
A	Young	Breathing periods	:50	1:15	1:30	:20	:30	1:00	:20	1:00	:30	:40	1:20		:50+
		Number of breaths	2	4	4	1	1	2	1	2	1	2	3		2:1−
		Resting periods	4:10	3:30	7:20	2:20	3:00	3:20	4:40	5:40	3:50	4:40	6:20		4:26+
	Male	Breathing periods	1:25	:25	1:10	:40	:30	1:00	:40						:50
		Number of breaths	3	1	3	2	2	3	2						2.3−
		Resting periods	9:00	4:40	8:25	6:40	5:10	7:40	7:40						7:02+
	Female	Breathing periods	1:20	:40	1:00	:50	:50								:56
		Number of breaths	3	2	3	2	2								2.4
		Resting periods	12:50	8:40	7:20	15:10	12:10								11:14
B	Young	Breathing periods	:20	:30	1:30	:20	1:20	:25	:20	:30	1:00	:20	:25	:20	:30	:36+
		Number of breaths	1	1	2	1	2	1	1	1	2	1	1	1	1	1.2+
		Resting periods	9:30	3:30	2:00	7:30	4:00	4:00	2:30	3:00	5:30	8:00	2:10	4:00	4:20	4:37−
	Male	Breathing periods	:30	3:30	2:00	:30	1:10	1:00	:50							1:21+
		Number of breaths	1	5	4	1	3	2	2							2.6−
		Resting periods	13:00	9:00	11:30	5:30	8:15	7:20	9:40							9:11−
	Female	Breathing periods	1:00	3:00	1:30	:20	1:00									1:22
		Number of breaths	3	4	3	1	3									2.8
		Resting periods	14:00	11:20	12:30	13:00	14:00									12:58

C	Young	Breathing periods	3:00	1:00	1:20	:30	:20	1:00	:20	:30	1:00	1:30	1:00			1:03−
		Number of breaths	2	2	2	1	1	2	1	1	2	3	2			1.7+
		Resting periods	4:00	6:30	6:10	6:20	2:10	4:50	5:00	4:20	3:10	4:50	5:20			4:47+
	Male	Breathing periods	:40	:50	:30	:20	1:20	1:00								:47−
		Number of breaths	2	2	1	1	2	2								1.7−
		Resting periods	10:30	9:50	10:40	8:20	9:30	10:10								9:50
	Female	Breathing periods	1:40	:50	2:00	1:30	1:50									1:34
		Number of breaths	3	2	3	2	3									2.6
		Resting periods	14:00	8:00	12:20	9:40	15:10									11:50

the lengths of breath, i.e., the time that the nostrils are open, is about the same for the young, 30− seconds, that it is for the male, 27+ seconds, and for the female, 30− seconds. In other words, the actual breathing operation occupies an interval of time which was about the same for all three manatees. This unit is used in small multiples by the young, 1.7− in larger multiples by the male, 2.2, and in still larger ones by the female, 2.6.

The interval between two breathing periods is the resting period during which the manatee is reposing quietly under water. During this interval the animal is cut off from its supply of air and hence the length of this period is a measure of its adaptation to submergence. The resting period in the young varied from 2 minutes to 9 minutes and 30 seconds with an average of 4 minutes and 37− seconds; in the male it ranged from 4 minutes and 40 seconds to 13 minutes with an

TABLE 2

Average breathing periods in minutes and seconds, average numbers of breaths in each breathing period, average resting period in minutes and seconds, and average length of breath in seconds for the three manatees recorded in table 1. The results are computed from the figures in that table

	YOUNG	MALE.	FEMALE.
Breathing periods	:49	1:00	1:17+
Number of breaths	1.7—	2.2	2.6
Resting periods	4:37—	8:38−	12:01−
Lengths of breath	:30—	:27+	:30−

average of 8 minutes and 38− seconds, and in the female it varied from 7 minutes and 20 seconds to 15 minutes and 10 seconds with an average of 12 minutes and 1− second. In general it may be said that taking the period of submergence in the young as unity that in the male was nearly two and that in the female nearly three.

As the young manatee was the smallest of the three, the male next in size, and the female the largest, there appears to be a fairly intimate relation between the size of the animal and its respiratory activities, for the larger the manatee the longer its breathing period, the greater its number of breaths in each such period and the longer it remained under water.

A number of other sets of records were taken from the manatees in addition to those given in table 1, but these sets were incomplete as compared with the three already tabulated in that, instead of extending

over an hour, they were shorter having been interrrupted by the unexpected resumption of swimming on the part of one or more of the manatees. Under such circumstances breathing became very much more rapid and the animals moved over the surface of the water in such a way that it was impossible to record accurately their respiratory activities. These incomplete records in so far as they appertain to resting animals show, however, nothing that is not to be seen in the complete records except a maximum period of submergence. In one instance among these incomplete sets the female is recorded as having remained under water 16 minutes and 20 seconds. This is the longest period for a manatee to be under water of which I have a record and exceeds the maxima in table 1 by over a minute. Aside from this the incomplete sets contain nothing of special interest.

It has been stated by some observers that the sea-cows are nocturnal in their habits, but the three animals that came under my observation showed no evidence of this. I often visited at night the pool in which they were kept and I never noticed at that time any greater activity in it than I did during the day time. In the darkness of night it was much more difficult to observe the manatees than in the day, but the large female could be commonly identified in the dim light of night and I have a number of sets of records of her breathing rate at that time. In obtaining these records I usually placed myself on the edge of the pool as close as possible to her head and listened for her breathing as she came to the surface reading the time from a watch kept near at hand and lighted by a flash-light so held as not to illuminate the pool. In this way I found that she was acting much as she did in the daytime and that her submergence or resting periods averaged about 12 minutes. In listening for her breathing I held my face as near the surface of the water as the edge of the pool would permit and on her first emergence she often blew her breath directly in my face. It was far from aromatic, as described by Drexler and Freund (1906, p. 80) for the dugong, but had a most repulsive smell resembling somewhat that of phosphorus. This may have been due to the fact that she with the other two in the pool were fed regularly on cabbage.

The periods of submergence for manatees recorded in this paper agree fairly well with those already contained in the literature. These older records were not very systematically gathered and most of them are of the nature of incidental notes rather than extended statements. The resting or submergence period for American manatees are given by the authors quoted as follows: Chapman (1875, p. 461) about 1 to

1¼ minutes, Brown (1878, p. 296) on the average 2½ minutes, Crane (1881, p. 457) 2 to 3 minutes with a maximum of 6 minutes, Noack (1887, p. 296) every 2 to 3 minutes, and Townsend (1904, p. 86) 5 to 8 minutes, a statement repeated by Gudernatsch (1908, p. 232). The African manatee is said by Noack (1887, p. 300) to come to the surface for breathing every 1½ to 2 minutes. The eastern sea-cow or dugong has been reported upon in the same incidental way and with much the same range. Thus Rüppell (1834, p. 113) stated that this sea-cow comes to the surface every minute or so for breathing; Klunzinger (1878, p. 68) gives the rate as once in 10 minutes; and Semon (1896, p. 317) as every 3 to 5 minutes. Dexler and Freund (1906, p. 80) observed the breathing rate in a newly captured dugong to vary from 17 to 65 seconds between breaths and in the imprisoned condition to vary from 43 to 145 seconds. Obviously these more rapid rates both for the manatee and for the dugong are to be ascribed to changes in the animal's activity and not to irregularities of observation, for, when a manatee begins to swim, it at once increases its rate of breathing which may rise to several times a minute. It is only with really quiet animals that such a period as 16 minutes or more is to be observed and then only when the animal is very large (3 meters long, for instance), conditions of observation which have rarely occurred in earlier work.

Florida and West Indian fishermen maintain that when the native manatee is hunted, it will dive and remain under water fully half an hour. Whether this is so or not remains to be seen, but it is not impossible that submergence periods exceeding considerably those given in this paper may be eventually reported.

The observations recorded in this paper show that manatees may remain under water much longer than diving birds or terrestrial mammals and that their normal periods of submergence are so considerable that they must be regarded as specially adapted to an aquatic life though they are obviously much less specialized in this respect than are the whales, porpoises, and other cetaceans. The fact that they bleed profusely when butchered and are what the fishermen call "full-blooded" is one feature in this adaptation, for their blood is probably their chief storage place for oxygen.

SUMMARY

The Florida manatee, *Trichechus latirostris* (Harlan), is highly specialized for an aquatic life. Its breathing is related to its size in that the larger the animal the longer it can stay under water, the

longer it breathes at the surface, and the more breaths it takes while breathing. A small manatee, less than 2 meters long, had an average breathing period of 49 seconds during which it averaged 1.7− breaths. A large manatee, three meters long, had an average breathing period of 1 minute and 17+ seconds during which it averaged 2.6 breaths.

The small manatee had an average submergence period of 4 minutes and 37− seconds with a maximum of 9 minutes and 30 seconds. The large one had an average submergence period of 12 minutes and 1− seconds with a maximum of 16 minutes and 20 seconds. These submergence periods far exceed those of diving birds and terrestrial mammals, but are not so long as those of cetaceans.

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